Space Weather Technical Forecast

Issued on Sunday, 15 September 2024 at 13:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

From the 24th of September, the way we distribute this forecast is changing and you will need to take action to continue receiving it. You should have received an email on the 4th of September explaining the steps required to do this. If you have already signed up to receive the forecast on our premium website, please disregard this message. If you haven't, or if you need help with the process, please contact moswoc@metoffice.gov.uk

Space Weather Forecast Headline: Further M-class flares expected with a chance of isolated X-class flares. G1-G2/Minor-Moderate Geomagnetic storms expected 16 Sep, with a chance of G3/Strong storm intervals and slight chance of peak G4/Severe storm conditions due to a forecast fast CME arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with a X4.5 flare observed at 14/1529 UTC originating from AR3825 in the southeast.

There are five sunspot regions on the disc with the most active being AR3825 in the southeast. The region exhibited growth in its intermediate and trailing spots, including development of a delta configuration. Emergence of AR3826 in the southwest into a small bipolar group occurred, but previous growth has slowed and has demonstrated only minor flare activity. AR3813, AR3815, AR3816 all rotated over the southwest horizon. The remaining regions on the disc were stable and inactive during the period.

A fast CME that was observed from AR3825 in the southeast occurring from the aforementioned X4.5 flare has been analysed as having an Earth-directed impact on day 2 (16 Sep). Numerous other CMEs were observed but these are not deemed to be Earth-directed.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as observed by ACE at L1, were slightly enhanced during the period, with wind speeds increasing from near background to between slightly elevated and elevated speeds, peaking 575 km/s at 15/0817 UTC. Density was below average throughout. The Interplanetary Magnetic Field (IMF) Bt, was Weak to Moderate, between 6-10nT, while the north-south component, Bz, was erratic, but often negative, peaking -7nT at 15/1116 UTC. Phi angle was largely positive (away from the Sun). The net result of these parameters was for Quiet to Active geomagnetic activity (Kp 2-4).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 has risen since the X4.5 flare, but remains below the S1/Minor Storm threshold at this time. High energy electron flux (greater than 2MeV) observed by GOES16, generally varied on a diurnal cycle between background and Moderate levels, but briefly peaked at 1070pfu (High levels) at 15/1120 UTC. The associated 24-hour fluence showed a generally flat trend, with 2.43e7 integrated pfu observed at 15/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity is forecast, with further M-flares expected, and a

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chance of isolated X-class flares, most likely from AR3825.

Solar Wind / Geomagnetic Activity: There are up to two CME arrivals and the potential for up to three coronal hole fast winds which feature in the forecast. The most significant feature is the 14 Sep CME which may bring Strong or Very Strong solar winds at Earth on day 2 (16 Sep), with a small chance this may arrive early, by late day 1 (15 Sep). This feature may have lingering effects into day 3 (17 Sep) combined with the second coronal hole fast wind. A third coronal hole fast wind may arrive day 4 (18 Sep), with slightly elevated to elevated speeds expected.

Generally Quiet to Active geomagnetic activity is expected day 1 (15 Sep) with a chance of G1-G3/Minor-Strong storm conditions and a very slight chance of G4/Severe storms should the 14 Sep CME arrive earlier than forecast. The 14 Sep CME should arrive on day 2 (16 Sep) with G1-G2/Minor-Moderate storming expected, but a chance of peak G3/Strong storm levels and a slight chance of G4/Severe storm intervals occurring. These risks reduce into days 3 and 4 (17 and 18 Sep) due to waning CME and coronal hole fast wind effects.

Energetic Particles / Solar Radiation: High energy proton flux at GOES-18 has risen after the X4.5 flare on 14 Sep, but remains below the S1/Minor Storm threshold. There is still a chance that S1 proton storm levels may be reached day 1 and 2 (15 and 16 Sep), this risk reducing later in the period. High energy electron flux is expected to rise to diurnally Moderate to High levels ahead of the CME arrival from 14 Sep flare, reducing to mainly background levels thereafter. The associated 24 hour fluence is expected to remain below Active (1e8pfu integrated flux) threshold, with a steady, then declining trend.

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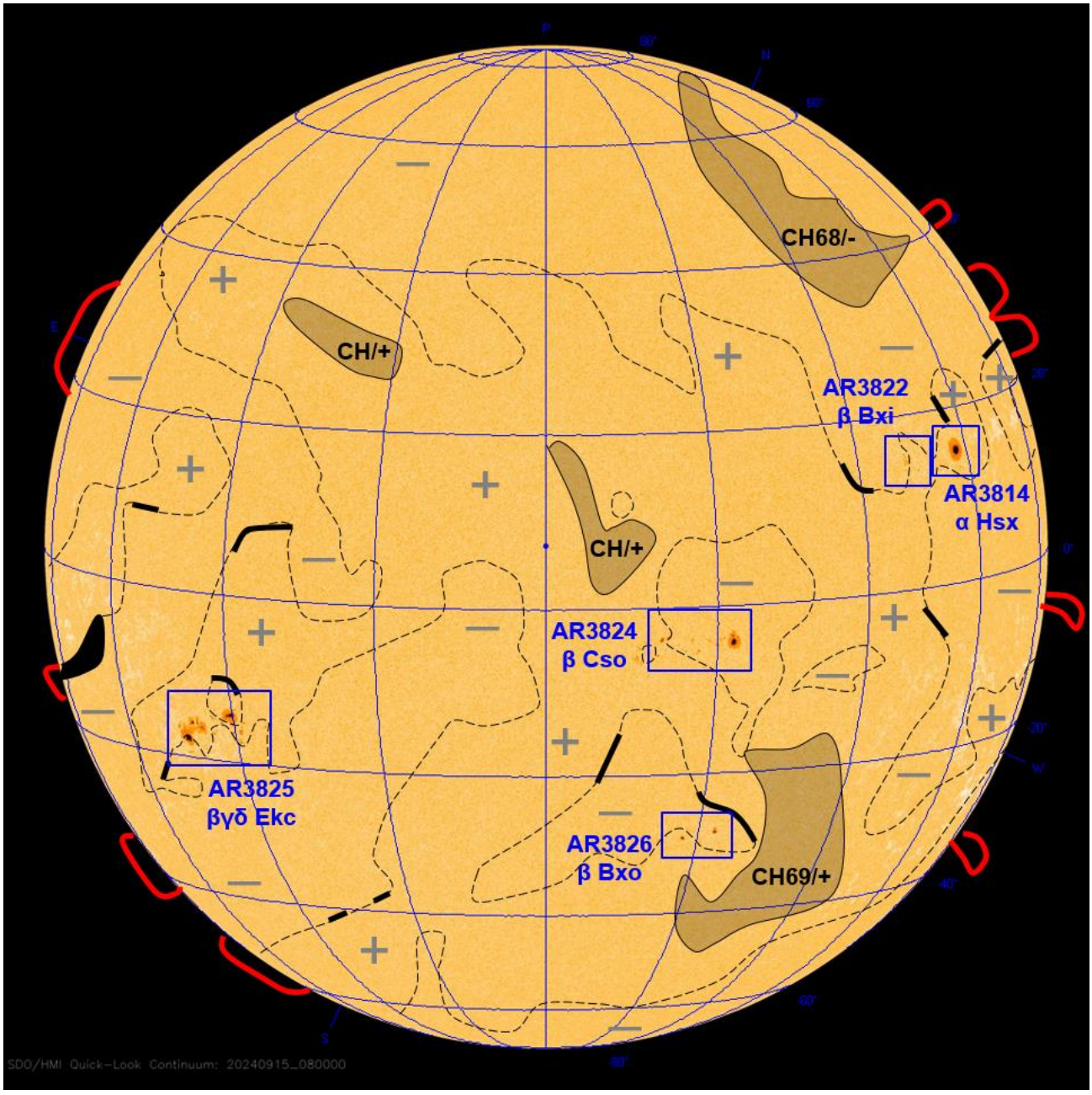
Figure 1. Solar Analysis Valid 15/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME was observed leaving the sun at around 13/0930 UTC, the result of a filament eruption, most likely associated with the M2.9 flare observed at 13/0835 UTC from AR3814. Its analysis revealed that the bulk of the ejecta is expected to pass ahead of Earth's orbit towards Stereo-A, however it may give a glancing blow on day 2 (16 Sep).

The most significant CME in the period originated from the X4.5 flare from AR3825 at 14/1528UTC. This spot was located around 55 degrees east at this time of the eruption, with subsequent analysis showing significant material being ejected directly away from the source in a narrow cone, but with a wider region of material also evident, this has been modelled with an arrival most likely during day 2 (16 Sep). There was also evidence of a faster shock visible beyond the opposing side of the Sun, giving clear Earth impacts from this shock also which may interact with Earth from very late on day 1 (15 Sep) before the bulk of the material arrives.

Aside from these arrivals, there are also up to three coronal holes which may influence the forecast. CH68/- is the most westward of these, with any high speed stream possibly connecting late on day 1 (15 Sep), but is both quite far north and unfavoured for a significant connection at this time of year. CH69/+ may then connect on day 2 (16 Sep). Confidence is low however, due to its southern location and Earth currently being above the solar equator in its orbit, though Enlil has consistently forecast strong solar winds (around 600km/s) on day 2 and 3 (16 and 17 Sep) from this feature. Finally, a small small positive coronal hole near centre disk may bring elevated wind speeds at Earth for a time. This is most likely to occur on day 4 (18 Sep) or perhaps later, though the fast wind from this feature may be masked by any CME effects in coming days.

Generally Quiet to Active geomagnetic activity is expected day 1 (15 Sep) with a chance of G1-G3/Minor-Strong storm conditions and a very slight chance of G4/Severe storms should the 14 Sep CME arrive earlier than forecast. The 14 Sep CME should arrive on day 2 (16 Sep) with G1-G2/Minor-Moderate storming expected, but a chance of peak G3/Strong storm levels and a slight chance of G4/Severe storm intervals occurring. These risks reduce into days 3 and 4 (17 and 18 Sep) due to waning CME and coronal hole fast wind effects.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	40	80	50	20
Strong	G3	No	20	40	20	2
Severe	G4	No	5	15	2	1
Extreme	G5	No	2	5	1	1

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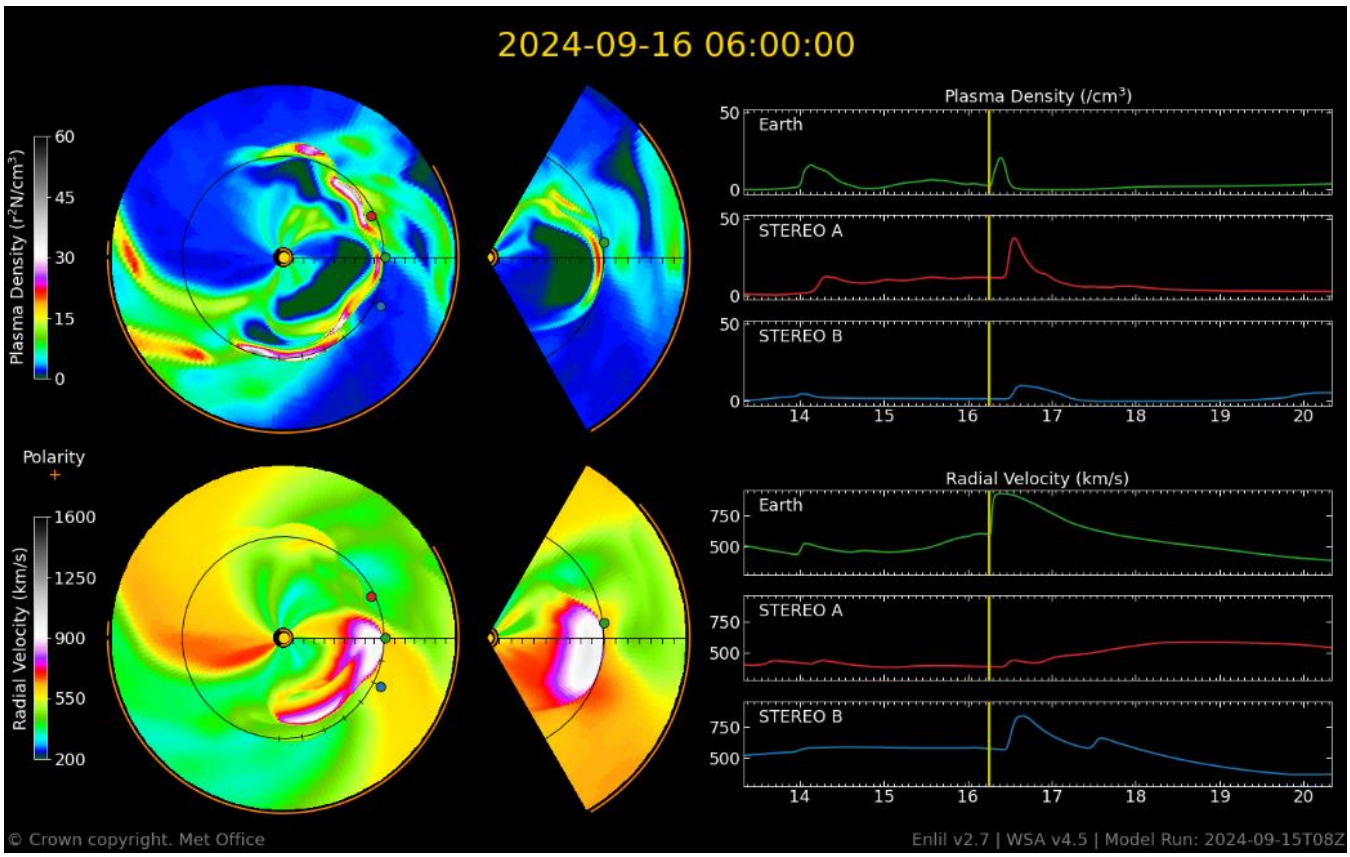
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/1818	Partial	AR3825	SE	1250km/s	16/0600 UTC +/- 6hrs	Possible shock prior to bulk material arrival at L1. Medium confidence.
*	*	*	*	*	*	*

Figure 2: MOSWOC Enlil output for 16/0600 UTC



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Radio Blackouts - X-Ray Flares:

Moderate to High activity is forecast, with further M-flares expected, and a chance of isolated X-class flares.

There are five sunspot regions on the disc with the most active being AR3825 in the southeast with a X4.5 flare observed at 14/1529 UTC. It is a compact and magnetically complex region, containing at least one delta spot in the trailing part of the group and with a history of multiple M class and another X class flare in recent days. A rapid adjustment in the penumbra around the trailing delta spot was observed at the time of the most recent X class flare, this has an inherently unstable north-south magnetic alignment. Moderately sized AR3822 in the southwest evolves slowly with some proliferation of intermediate pores or spots, but it appears stable with limited flaring.

The remaining regions are small, with limited magnetic complexity.

Further M-class flares are considered likely, with a slight chance of further isolated X-class flares, most likely from AR3825, this is held constant throughout the period due to AR3825 being the dominant spot on the disk which holds almost the entirety of the risk of flare risk.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	Yes	20	20	20	20

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Solar Radiation Storms - (High Energy Protons):

High energy proton flux at GOES-18 has risen to moderate levels after the X4.5 flare on 14 Sep. A rising trend continues to be observed, although remains slow. Therefore is considered to be a chance that S1 proton storm levels may be reached day 1 and day 2 (15 and 16 Sep), this risk reducing later in the period to a slight chance in the absence of any further notable flaring.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	30	20	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux has been rising to Moderate, briefly High levels during the recent diurnal maximums due to recent geomagnetic storming that took place on 12 Sep. Now with at least two further CME arrivals anticipated and up to two coronal hole fast wind arrivals in the period, any rise is expected to be brief and the high energy flux most likely to return to mainly Background levels.

The associated 24-hour fluence is expected to remain below the Active level. The latest MOSWOC REFM output is currently showing a generally steady fluence forecast rise, however this is misleading as it isn't taking into account any CME impacts or possible coronal hole interactions in the coming days.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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